perhaps in a few places, are regarded as presenting no special urgency. The same applies on the whole to Malaysia, where very little intensive work has been done as yet. Parts of New Guinea and the larger islands of Melanesia can well be left for the present, others require immediate investigation, as do all the smaller islands. "There is probably no part of the world where a larger amount of valuable material can be saved during the next few years than in Melanesia, and yet at the present moment little or nothing is being done." Much work and this of great urgency remains to be accomplished in Australia. "A thorough survey of Polynesia will yet provide material of the utmost value to the ethnologist." "In Micronesia the conditions are more satisfactory . . . but there still remain . . . islands, such as the Gilbert and Ellice Groups, about which our existing knowledge is trivial." He concludes by saying:

"Two regions, southern Africa and Oceania, combine an extreme degree of the urgency of their needs with very inadequate attempts to meet those needs. Of these regions it is suggested that Oceania should have the preference. It includes places where interesting and important examples of human culture are on the verge of extinction and other places which are in a condition especially suited for intensive work, so that a large mass of valuable material can be obtained with relative ease. Through its insular character Oceania presents conditions of especial importance in the study of certain theoretical problems, and it has a special interest in that its culture stands in close relation to that of the American continents. It is suggested that the study of a region allied in culture to that of America may react on the study of American ethnology, and may prove the best means of reaching positive conclusions concerning the exact nature of the indigenous culture of America."

Prof. Jenks gives a brief account of the subject-matter and present status of anthropology. In a section entitled "Research problems and opportunities in Anthropology," he deals solely with the Indo-Pacific and American areas. For the former he takes as his main theme the problem of the origin and spread of the Pacific islanders and their culture, and remarks that "Churchill recently has largely solved the Polynesia migration problem in the Pacific Ocean." He suggests that in Polynesia "a true knowledge of the genesis of the speech of man" possibly may be discovered, and quotes from Churchill that the Polynesian languages are of "the most elemental character," and the "parts of speech have but just begun to make their appearance." Churchill even says positively that "we find ourselves engaged with a language family in which we can discover the beginnings of human speech." These statements are very remarkable if it be true, as other linguists assert, that the Melanesian variants of the Austronesian languages exhibit more primitive features than the Polynesian (Codrington definitely states that the Polynesian group of languages is "late, simplified, and decayed" as compared with the Melanesian), and if we are to look for the "primeval home" of the Polynesians in the Ganges Valley. One would like to have the evidence for Churchill's statement that "the Tongafiti migration has left absolutely no trace of its passage in Melanesia." Prof. Jenks refers to certain problems, such as the decay and loss of culture forms, and to prehistoric stone remains, and he recommends further excavations at Trinil for *Pithecanthropus erectus*, and a study of the individual and communal life of the orang-utan.

The antiquity and origin of man in America, and the origin and spread of aboriginal American culture are put forward as special questions requiring to be decided. The solution of the problem of the "extra-American origin of culture . . . would contribute not only to the present subject, but to the anthropological world-problem of culture similarities—whether similar cultural expressions in isolated areas had a common origin, or independent origins, or are due to transmission." Three of the most important modern anthropological problems of the Western hemisphere and the Pacific islands, of which Prof. Jenks advocates the study, are ethnic heredity, influence of environment on mankind, and human amalgamation, and he proposes that a permanent laboratory should be established eventually in connection with these studies.

Mr. Sylvanus G. Morley makes a strong appeal in his beautifully illustrated essay for a prolonged and thorough investigation of the great group of ruins at Chichen Itza in northern Yucatan. It is his belief "that no other archæological field in the New World offers such rich promise as the region occupied by the ancient Maya, and, at the same time, no equally important field has been so inadequately studied."

The facts and arguments adduced by Dr. Rivers and Prof. Jenks point clearly to Oceania as being probably that part of the world which most urgently needs ethnographical investigation, and if the Carnegie Institution could see its way to organise a commission for the intensive study of as many portions of that area as possible, combined with an investigation of the more general problems of racial and cultural movements, it would confer an incalculable boon on all present and future students of the history of human culture. If this be not attempted very soon the opportunity will pass away for ever.

A. C. Haddon.

THE PRINCIPLE OF RELATIVITY.[1]

II.

At the root of what are generally thought of as our intuitive notions of space and time lies the conception of simultaneous instants at different points. The sensations by which we actually perceive bodies are, strictly speaking, not distributed through space; but the mental picture which we construct of the phenomena is ordered under the categories of time and space, and in this way of ordering the idea of simultaneous events at different places is essential.

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[1] Continued from p. 379.

Now the very first thing that appears, if we accept the hypothesis of relativity, is that it is impossible for us to determine uniquely whether two events are or are not simultaneous. This can be best illustrated by a simple ideal experiment. Retaining for the present the conception of a unique stationary æther, let us suppose that two points A, B, are moving relative to it with the same velocity v, and let c be the velocity of light. Now imagine a ray of light to be sent out from A at an instant t_1, in the direction A B. Let this ray arrive at B at the instant t_2. Let it then be reflected back to A, arriving there at the instant t_3. Now if the distance A B is l, since the relative velocity of the light on the outward journey is $(c-v)$, we have

$$t_2 - t_1 = l/(c-v),$$

and similarly since the relative velocity on the return is $(c+v)$,

$$t_3 - t_2 = l/(c+v).$$

From these equations we obtain

$$t_2 = t_1 + t_3/2 + lv/(c^2 - v^2).$$

Now if the velocity v were zero, we should have the result that the moment of reflection at B is simultaneous with the moment $\frac{1}{2}(t_1+t_3)$, that is, with the moment at A midway between those of emission and return of the ray. But if the velocity v is unknown, which is the hypothesis with which we are dealing, then we cannot say from this experiment what instant at A is simultaneous with the instant t_2 at B.

Now no man of science should say, of course, that because he does not know, or cannot determine a thing, that, therefore, it does not exist. We have no right to say that, because we cannot determine our velocity relative to the æther that therefore the æther *cannot* exist. So we do not say that the conception of "simultaneity" is an absurdity; what we do say is that the notion is not an intuitive one, forced upon us with a unique significance apart from all material phenomena; but that it is a convenient element in our ways of thinking about phenomena, and is really inseparable from the whole body of thought about them, that is, from the laws by which we conveniently describe their sequences.

In the light of the simple experiment described above, therefore, we find that the conception of "simultaneity" does not become definite until we have assigned a definite velocity to a certain point, which may conveniently be our own point of observation.

The next thing we may notice is that the notion of the "length of a body" becomes indefinite along with the term "simultaneous." For in our usual ways of thinking, the length of a body is the same as, is in fact defined to be, the distance between two points of our universal frame of reference, with which the ends of the body "simultaneously coincide." Until we have made the last phrase definite, the length of a body is either indefinite, or else it must be defined in some other way, in which case we might have a contradiction between the definition of length and the derived concept of measurable space.

In the light of these difficulties we may be prepared to reconsider our preconceived notions of the measures of space and time and what is implied in respect of them by the laws which we find to be the best expression of the order which we have disentangled from the complex of physical phenomena, including among those laws the principle of relativity.

As was stated at the beginning, this includes the statement that it is impossible for an observer to detect a difference between the velocities of light in different directions, whatever may be his own motion. In other words, the propagation of light through space is supposed to be expressible as a uniform propagation in all directions with velocity c whatever velocity the observer supposes himself to have. This is a self-contradictory assumption if we adhere to the space and time which we use in Newtonian dynamics, where the relative velocity of two points is just their difference. But if we grant that our measures of space and time are, as has been suggested above, modes of thought inseparable from the laws into which they enter, then we realise that what we have been in the habit of looking upon as assured and permanent elements in our thought may, with the development of our knowledge of the physical world, come to require modification.

If now we start from the fundamental law that there is a definite physically-determined velocity, that of light, an invariant element in the physical world, we can proceed by an algebraic process to examine what variety is possible in the quantities by which we measure space and time. This is a problem capable of complete solution, and when it is carried out we find that there is a large degree of arbitrariness. It appears that out of all the possible systems of measurement so obtained we can always find one such that all points at rest in this system have an arbitrary uniform velocity in any other given system. If this velocity is v and if two simultaneous events as estimated in the time variable of the first system occur at two points at distance l apart on a line parallel to v, then as estimated in the second space-time system, they occur at instants separated by a time $lv/c(c^2-v^2)^{\frac{1}{2}}$, at points the distance apart of which is $cl/(c^2-v^2)^{\frac{1}{2}}$.

The remarkable thing is that when we have developed this infinite number of ways of measuring space and time out of the single hypothesis of the universal value of the velocity of light, we are able to show further that the whole set of laws of the electromagnetic field may be retained in the same form whichever of the systems of measurement we adopt. Thus we find that not only space and time, but the physical quantities, electric and magnetic intensity, and the force on a charged body, are quantities which are "relative," that is, which are only uniquely defined after the choice of the system of reference has been made; that is, after we have stated in advance what velocity we assign to some one particular point of the moving bodies.

It appears too that the acceleration of a moving point has a relative magnitude, and so we find that the ratio of the force on a small charged body to the acceleration produced in it, is also a quantity which depends on the particular frame of reference used; the directions of the force and the acceleration cannot even be taken to be the same in all systems of measurement; that is, the acceptance of our fundamental hypothesis makes it impossible to maintain the Newtonian conception of "constant mass." The modifications required in the dynamical laws are, however, borne out by the results of the well-known experiments on the variable inertia of the negative electrons which constitute the kathode rays and the β rays, particles the velocities of which are so great that the deviation from the ordinary laws are considerable.

A more important question even than that of the mass of the electron is that as to whether this modification in dynamical laws is allowable in the light of the enormous mass of support which the older theory receives from its agreement with the facts of planetary motion. All that can be said here is that with the modified conception of mass, and a modification of the law of gravitation which attributes to it the velocity of light and a deviation from the inverse square rule of such a kind as to make it consistent with the relativity of forces, de Sitter has shown that there is complete accord between existing observations and the demands of the hypothesis of relativity.

The Aether.

It was emphasised above that the stationary æther as it is commonly conceived is in reality nothing more than a mathematical frame of reference. Now we have seen that this frame of reference is not unique. Does the æther, therefore, not exist? We can certainly say that, if it exists, it is not to be identified with the frame of reference. What we want is to be able to reconcile the idea of a unique medium, which is the mechanism by which electrical effects are transmitted, with the mathematical equations which do not determine a unique frame of reference. This cannot be done except by attaching some concrete significance to the electrical magnitudes in terms of the constitution, motion, or distortion of this medium. As we at present know them, the terms "electric intensity," "magnetic force," "motion of the æther," have only a relative significance. If we contemplate an objective æther it might be possible to construct out of relative quantities depending on the motion of the æther a quantity which would have exactly the same kind of relativity as the electric intensity for example; that is, the electric intensity might be put into unique definition in terms of the æther, though both are only expressed relatively in terms of the frame of reference.

The principle of relativity then does not deny the existence of an æthereal medium; that is only the interpretation of an individual. What it does do is to emphasise the insufficiency of the existing conceptions of the æther, and to set up a criterion by means of which suggestions as to the nature of the æther may be examined.

E. Cunningham.

PROF. HUGO KRONECKER, FOR.MEM.R.S.

On Saturday, June 6, Hugo Kronecker, one of the first rank of living physiologists, died suddenly of apoplexy. Although he was seventy-five years of age, his intellect was as keen, his energy as great, and his unselfishness as unbounded as at any time in his life. This is saying much, for these characters had been his in no ordinary measure. His life's work consisted chiefly of investigations into the contractility of muscle, the movements of the heart, and the effect upon it of rarefied air. He discovered almost simultaneously with Marey the curious fact that during one period of its cycle the ventricle will not respond to stimuli. To this time Marey gave the name of refractory period. He found also that there is a point generally known as Kronecker's point in the heart, puncture of which causes the heart to stop at once and permanently. His investigations on the effect of rarefied air upon the circulation convinced him that the ascent even to considerable altitudes if unaccompanied by muscular strain is without danger, and on his report to this effect the building of the well-known Jungfrau Tunnel was begun and is now nearly completed.

Kronecker was at one time private assistant to the great physician, L. Traube, and thus possessed a knowledge of medicine quite unusual amongst mere physiologists. He was one of C. Ludwig's most esteemed pupils and dearest friends, and was at one time his assistant. At Leipzig and elsewhere he became acquainted with almost every physiologist of note, and his linguistic powers, his extensive knowledge of an encyclopædic character, his geniality, kindness, and trustworthiness converted every acquaintance he made into a friend.

Like Ludwig, Kronecker published a great deal of his work under the names of his pupils, amongst whom may be mentioned Dr. Gustav Hamel, father of the aeronaut, whose untimely death the world has recently had to deplore, and Prof. Meltzer, of the Rockefeller Institute. His influence in stimulating others was enormous, and as director of the Marey Institute in Paris, as professor in Berne, and as an actual participator in most of the physiological congresses, he put at the service of everyone who was willing to work his knowledge, his time, and his energy without stint.

The esteem in which Kronecker was held is shown by the Universities of Glasgow, Aberdeen, St. Andrews, and Edinburgh having conferred upon him the degree of LL.D., and Cambridge that of D.Sc. The number of distinctions conferred upon him by foreign universities and learned bodies is